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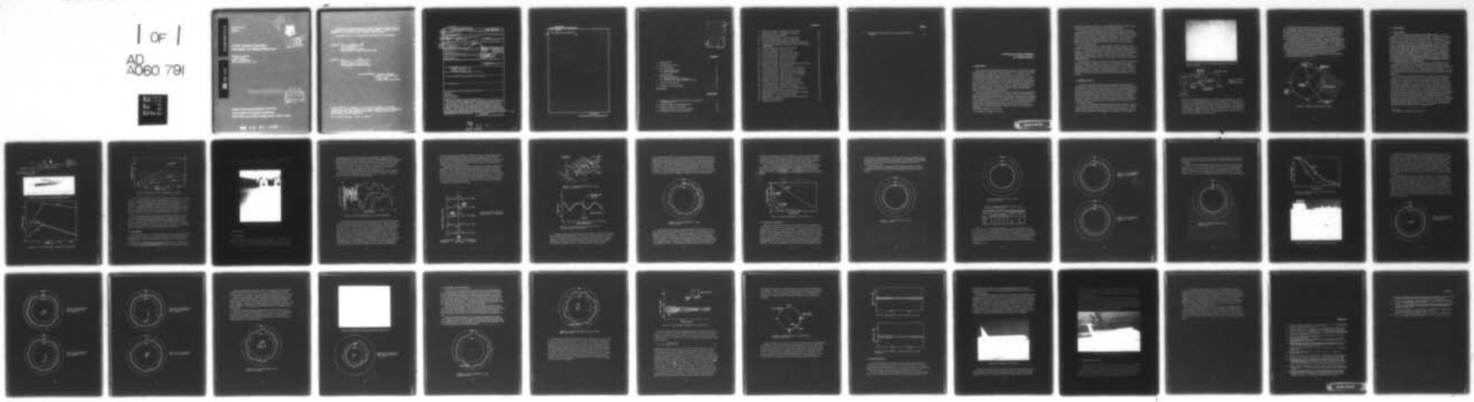

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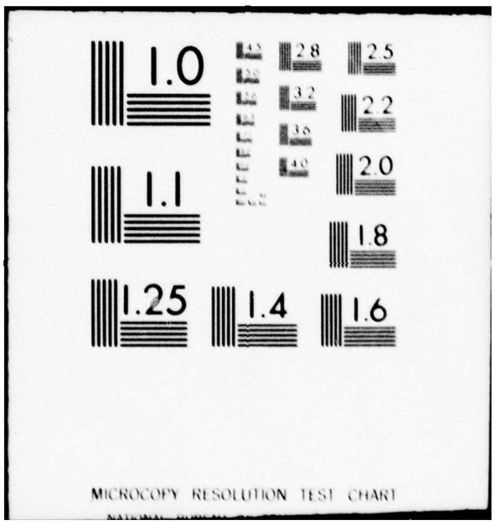
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A VHF Intrusion Detection Technique for Isolated Resources

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A mobile rf intruder detection system for isolated or clustered high value resources has been successfully tested. Because the system operates in the very high frequency (VHF) range, there is little shadowing from aircraft or vehicle structures. Also, since human body size is comparable to the wavelength at these frequencies, the electromagnetic fields interact strongly with intruders. This response makes detection easier and helps to eliminate false alarms caused by small animals, wind-blown debris, and other similar objects. The experimental results show that the technique has a low false-alarm rate (OVER)

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A VHF Intrusion Detection Technique for Isolated Resources

1. INTRODUCTION

This report is one of several dealing with a new type of radio frequency intruder detection system for isolated high-value resources.*[1,2,3] The need for developing a viable operational system for the military services and civilian government agencies has been continually emphasized in official reports, as well as in commercial publications.[4] Specifications for a quick-reaction security system that can be used to protect isolated valuable resources have been established by the Electronics Systems Division, Air Force Systems Command.[5,6] The system described in this report can be used to protect individual or clustered vehicles, storage areas, field sites, and parked aircraft. It can be used either as a quick-reaction portable system, or as a permanently-installed system.

Other security systems now in use have many deficiencies that limit applicability and impair their detection capabilities; for example, microwave frequency doppler radars, when positioned under an aircraft, are subject to shadowing from the landing gear, the engine nacelles, and even the fuselage itself; this is particularly apparent for aircraft such as the C-5A which is only 15 in. above the ground when lowered to receive cargo. Beam breaker radars require three or four units to enclose a resource and are subject to blind spots. Infrared, acoustic, and optical systems

(Received for publication 26 July 1978)

*For References 1 through 6, see p. 39.

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are difficult to maintain. However, the most significant problem common to many existing systems is a high false-alarm rate during windy periods.

The new sensor system eliminates many of the deficiencies associated with present systems because it operates in the VHF range; for example the wavelengths employed cause a reduction in the shadowing effects from aircraft structure. Also, the size of a human intruder is comparable to wavelengths at VHF, so the electromagnetic fields interact strongly with humans. This not only makes detection easier, but also helps to differentiate nuisance alarms caused by small animals, birds, and wind-blown debris.

The VHF individual resource intruder detection system is comprised of a distributed transmitting element, a receiving element, and associated signal processing circuitry. The transmitting element is a length of leaky (ported) coaxial cable on the ground, looped around the resource to be protected. A centrally located antenna receives the radiated signal. When an intruder crosses the cable, the received signal changes from its quiescent level. This change is then detected and processed, setting off an alarm.

An experimental program was developed to evaluate the operation of this system. Tests were designed to establish the validity of the underlying electromagnetic principles, to observe performance in a realistic environment, and to identify any weaknesses where further refinement would be necessary. Results of these tests, which were generally successful, will be discussed later in the report. Section 2 will deal with a description of the experiment and leaky coaxial cables used for the sensors.

2. EXPERIMENTAL SETUP

The tests to be described in this report were designed mainly to assess the electromagnetic fields associated with the sensor cables. No signal processing was employed since it could affect interpretation of the measured field distribution. Even though these measurements were made with laboratory equipment, a self-contained system has been designed, constructed, and tested in another set of experiments. This system, pictured in Figure 1, contains a receiver, transmitter, threshold detector, and an analog processor which rejects signal variations not produced by intruders. Further, it has provisions for self-testing and can produce a local or remote intrusion alarm.

A sketch of the experimental setup used during these tests is shown in Figure 2. A circle of leaky coaxial cable was excited by the transmitter section of a network analyzer while a monopole, usually centered within the cable perimeter, was connected to the receiver section of the analyzer. In the absence of an intruder, the

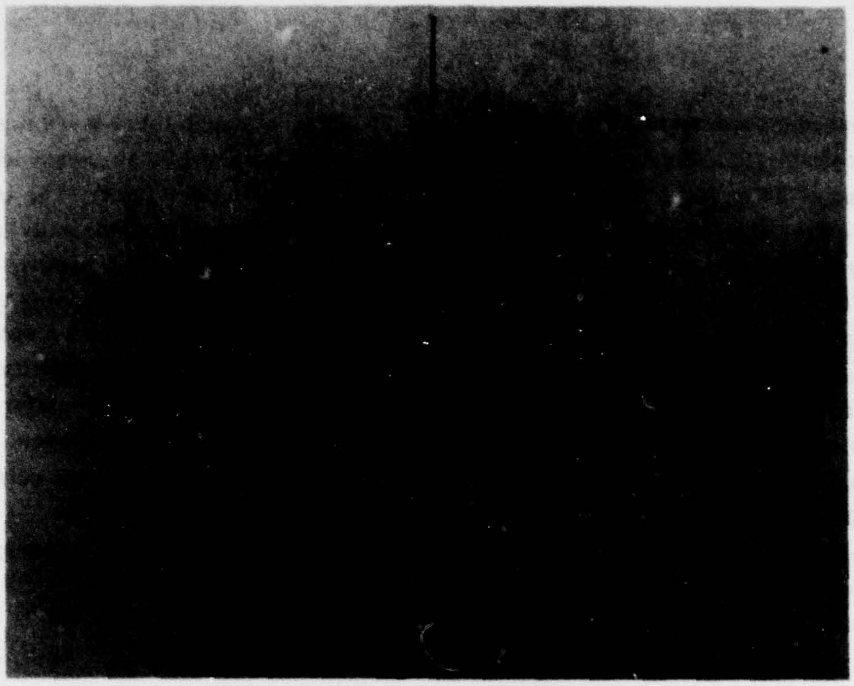

Figure 1. Photograph of Complete Portable Electronic Circuitry for Detection System

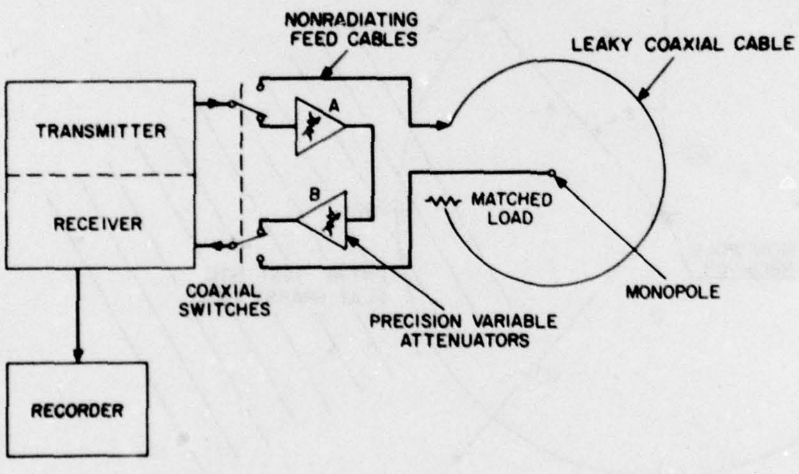

Figure 2. Schematic Diagram of Experimental Setup

leaky coax-to-monopole coupling loss so measured, remained constant. However, the presence of an intruder near the cable sensor modified the coupling loss and produced a corresponding change in the output of the network analyzer. This signal was recorded on the Y-axis of a recorder whose X-axis was calibrated in azimuthal angle, radial distance, tangential distance, or time, as appropriate. Two attenuators and a pair of coaxial switches were used to calibrate the receiver-recorder and to compensate for the attenuation in the feed cables.

Most measurements were performed at 75 MHz, although there were some at other frequencies. Since the results at 75 MHz are similar to those frequencies in the range of 50 to 100 MHz, only data for the 75 MHz are given here. The input power to the cable was 1 mW, although the radiated power was considerably less because leaky coaxial cable is a very inefficient radiator. The leaky coax-to-monopole coupling loss ranged from -60 to -100 dB, a value of -85 dB being typical.

The tests were conducted in an open, grassy field. Figure 3 shows a schematic of the layout and defines the azimuth angle θ and the radius ρ used to identify the paths of the circumferential and radial intrusion simulations. The circumferential walks started at zero degrees and continued clockwise around the perimeter. Radial crossings were made at several different points along the cable, starting outside the cable perimeter and proceeding toward the center along a radial line.

Before consideration of the results of the measurements, a brief description of sensor cables will be given in Section 3.

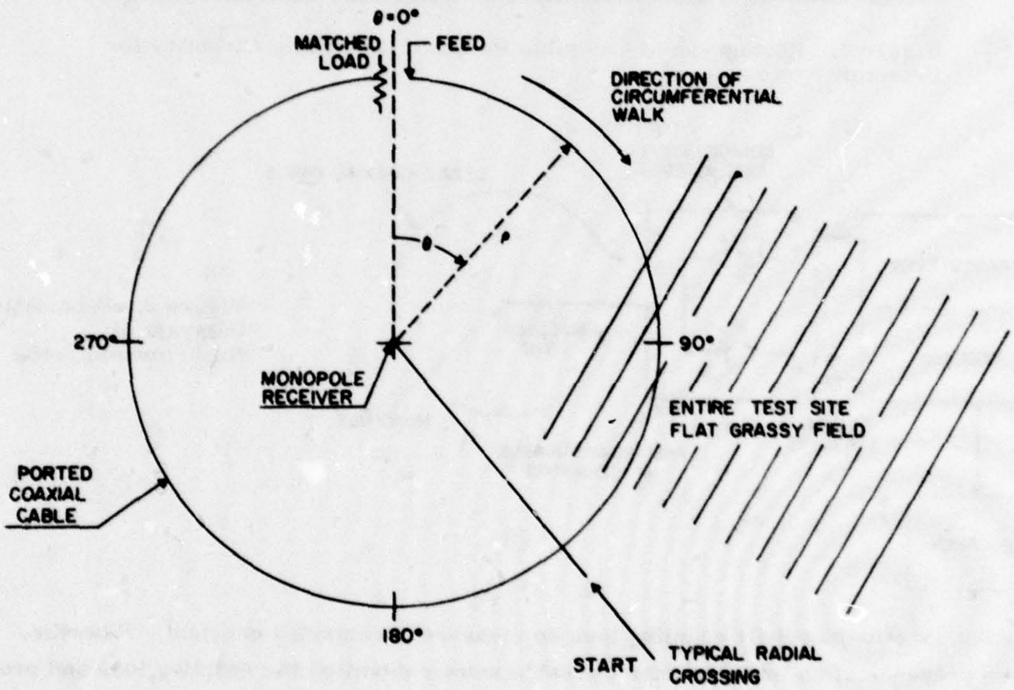

Figure 3. Schematic Layout of Field Test Site

3. SYSTEM SENSORS

3.1 Leaky Coaxial Cable

A sketch of a section of leaky coaxial cable is shown in Figure 4. The construction is typical of cables with solid outer conductors. The slots cut in the outer conductor cause a fraction of the energy inside the cable to leak therefrom, the amount being proportional to slot size and density. Some of the energy is radiated, but for the most part it remains closely bound to the cable. Cables with solid outer conductors are heavy and inflexible, making them unsuited for use in a portable system that requires quick setup by one or two people. For this reason, a more flexible leaky coaxial cable, CERT-285[7,8] was chosen (Figure 5).* In place of the solid outer conductor, the CERT cable has a strip of thin metal foil whose width is narrower than the circumference of the inner dielectric, forming a continuous longitudinal slot. This slot is interrupted by helically-wound wires. The amount of energy which leaks out is controlled by the width of the longitudinal slot and the spacing between the turns of the helical wires.

An external rf signal can also be coupled into the cable through the slots and propagated back along the cable. These cables have been used in paging systems, train radio communication systems,[9,10] and intruder detection systems.[11,12,13,14] General theoretical analyses of ported coaxial cables have been published,[15] as well as experimental data for ported cables with coupling slots having different sizes and shapes.[16]

Two parameters of a leaky coaxial cable are important when considering the cable for use as an intrusion sensor: first, attenuation and second, coupling loss. Attenuation is a measure of the rate at which a signal propagating within a cable weakens, and a coupling loss, a measure of the amount of this signal that leaks out of the cable and radiates to a nearby receiving antenna. The coupling loss is most often defined in terms of the signal power loss in decibels between the cable input and a dipole located 20 ft from the cable. For this measurement, the cable should be several hundred feet long and the dipole located near its center to avoid anomalous end effects that can yield misleading results. The coupling loss observed with the dipole at one spacing can vary over a wide range of values because of the complex structure of the fields surrounding the leaky coaxial cables. Therefore, the coupling loss associated with a specific cable type represents the average of several values observed for spacings ranging from 10 to 30 ft. The coupling loss and attenuation of three leaky coaxial cables are shown in Figures 6 and 7.

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*For References 7 through 16, see pp. 39-40.

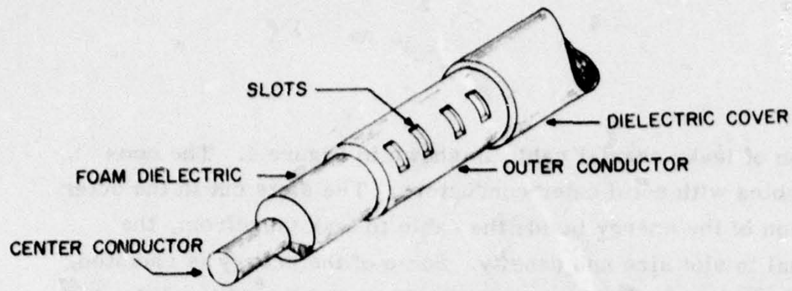

Figure 4. Construction Details of Ported Coaxial Cable

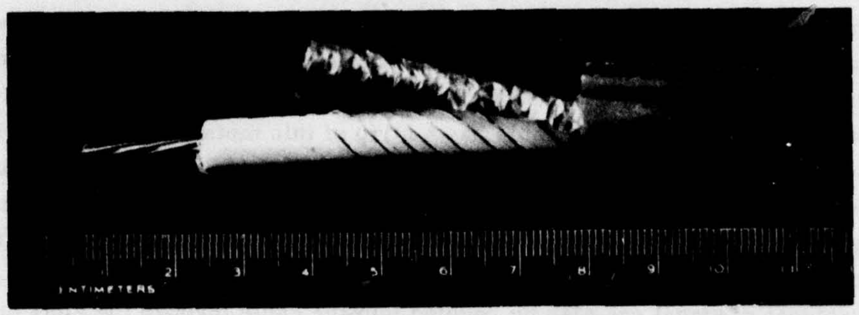

Figure 5. Photograph of CERT Ported Coaxial Cable

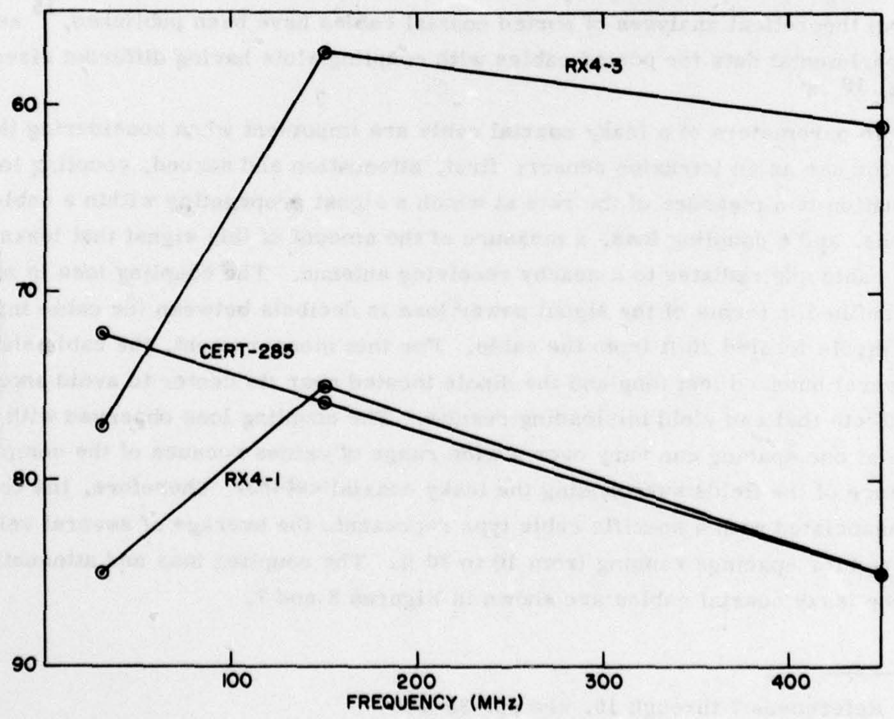

Figure 6. Ported Coaxial Cables - Coupling Loss vs Frequency

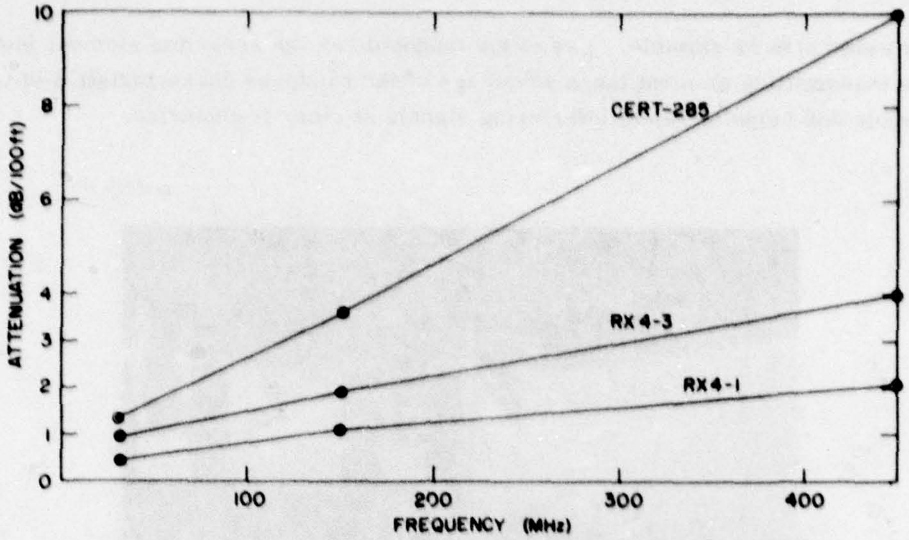

Figure 7. Ported Coaxial Cables - Attenuation vs Frequency

Radiax[17, 18] cables (RX4-1, RX4-3) have solid outer conductors, and the CERT-285 has a metal foil outer conductor, as discussed earlier. At the experiment frequency of 75 MHz, the coupling loss for the CERT-285, is approximately -73 dB compared to -70 dB and -80 dB for the RX4-3 and RX4-1 cables, respectively. The spread in coupling loss is moderate, with the CERT cable coupling loss falling between the other two values. However, the attenuation of the CERT-285 is higher than either of the radiax cables: in dB/100 ft, CERT-285 = 2.25, RX4-3 = 1.75, RX4-1 = 0.75.

Since the maximum cable length required in this system is less than 1500 ft, cable attenuation is less critical, and flexibility and weight are more important factors. The CERT cable is flexible and is 1/3 the weight of the Radiax cable. New types of flexible leaky coaxial cables only 1/4 in. in diameter and weighing as little as 15 lb per 1000 ft are currently being developed; these cables may be better suited for portable systems where the cable must be moved quickly.

3.2 Receiving Element

The receiving element used for these experiments was the quarter-wavelength monopole shown in Figure 8. At 75 MHz the antenna was about 3.25 ft long. No attempt was made to shorten the monopole by loading it. Several other antenna

17. Bulletin 1058A, Radiax Slotted Coaxial Cable, Andrew Corp., Orland Park, Ill.
18. Catalog 28, Antennas/Transmission Lines, Andrew Corp., Orland Park, Ill.

types would also be suitable. Use of the monopole as the receiving element instead of the transmitting element takes advantage of the bandpass characteristics of the monopole and helps to reject interfering signals at other frequencies.

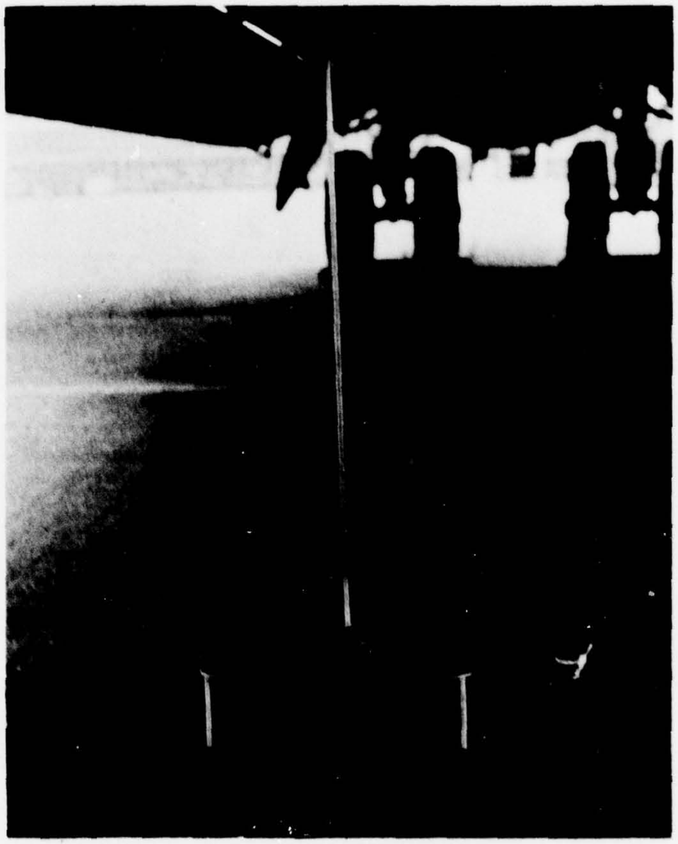

Figure 8. Photograph of Receiving Element

4. MEASUREMENTS

4.1 General Discussion

The measurements consisted in recording the variations in coupling loss as an intruder penetrated the zone of protection, which follows the contour of the cable. Figure 9 shows this variation in coupling during a circumferential walk. The periodic variation in level is the result of the interaction of the quiescent field with the

perturbing field produced by the intruder which continually changes phase as he moves along the cable. The wavelength of this fast variation depends on the operating frequency and the propagation velocity of the fields on the cable. The slower variations result from the interaction of the surface waves on the cable with the coaxial energy inside the cable. The period of this oscillation depends on the relative velocities of the energies traveling inside and outside the cables.

It is the excursion of the signal away from its quiescent value which is detected and used to declare the presence of an intruder. Thus the magnitude of the excursion is a measure of the sensitivity of the system.

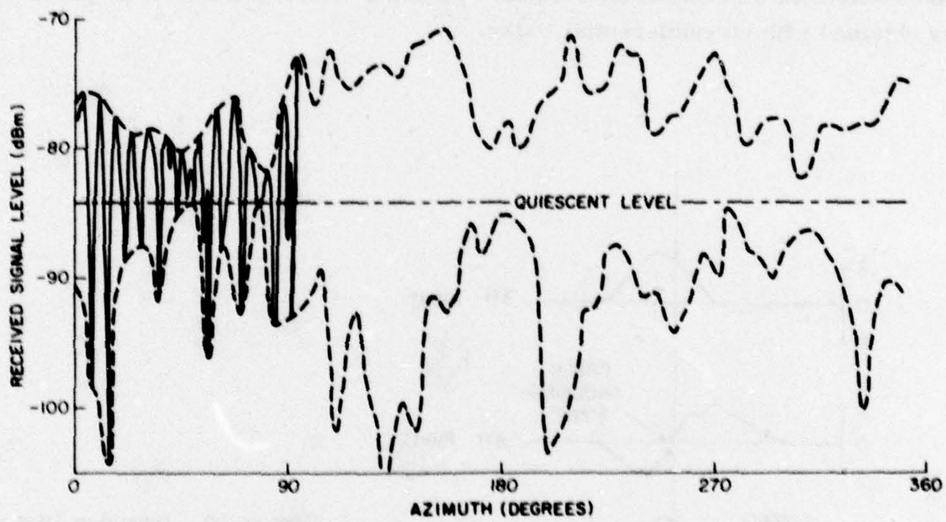

Figure 9. Received Signal Amplitude - Circumferential Walk

An examination of the circumferential response in Figure 9 shows that the signal periodically assumes the quiescent value equivalent to zero output. To determine if an intruder would be detected if he approached along a radial path that intersected the cable pe meter at one of these zero-crossing points, the response was also observed as a function of the intruder's location along a radial. Figure 10 shows the results for several walks centered around the 315° radial, typical of the general behavior for any radial path. Along each of the five paths, the maximum value of the response occurred at a different distance from the cable. For the 3-ft right path, the zero-crossing point occurred at the cable. Thus at this location, the circumferential and radial responses have the value of the quiescent signal, producing no detection. However, an intruder would have produced a strong signal

2 ft away from the cable, resulting in a detection. Figure 11 shows the data of the previous figure plotted in an isometric format to demonstrate more clearly the three-dimensional distribution of the detection fields around the cable. Thus for any radial path, it is not possible to traverse the area around the cable without intercepting a region of strong interaction.

Additional measurements were made to demonstrate a correlation between the response produced during a circumferential walk and that produced during radial intrusions. These results are shown in Figure 12 where the solid line shows the values for part of a circumferential walk. The data points are the values of coupling loss at the points where the radial and circumferential paths intersect. The excellent correlation between the two allows system performance to be assessed with the more convenient circumferential walks. Thus the bulk of the data to be presented was obtained with circumferential walks.

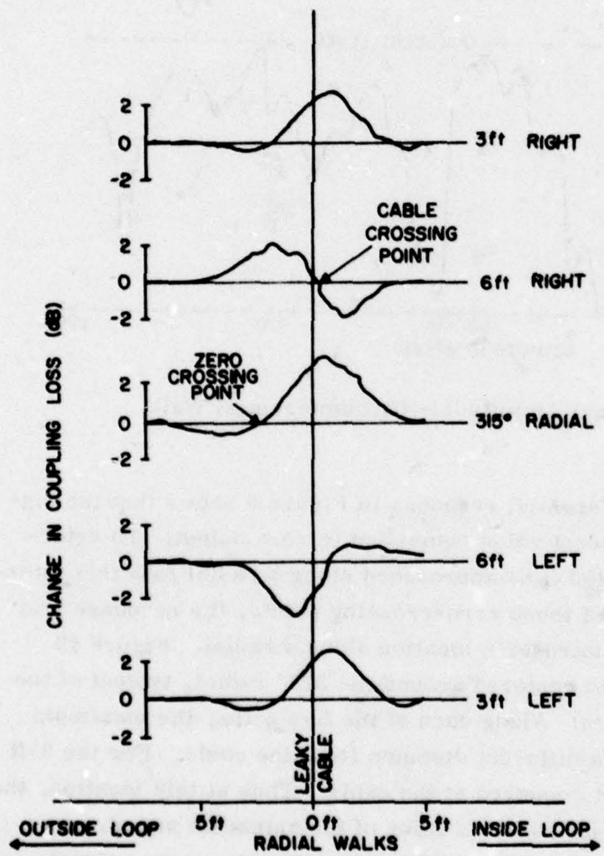

Figure 10. Intruder Disturbed Signal Amplitude - Radial Walk

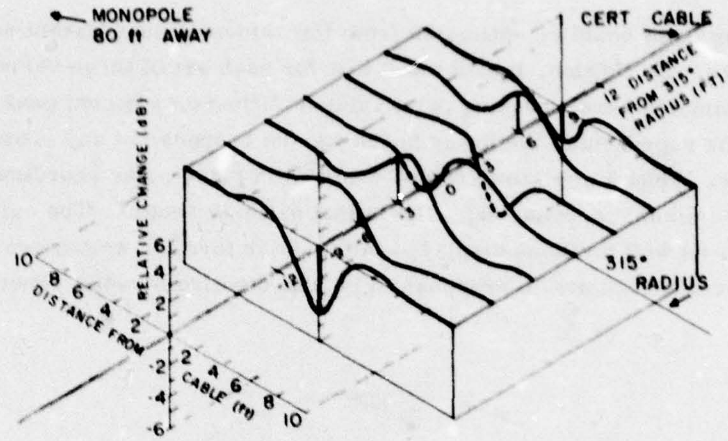

Figure 11. Composite Intruder Disturbed Signal Amplitude - Radial Walk

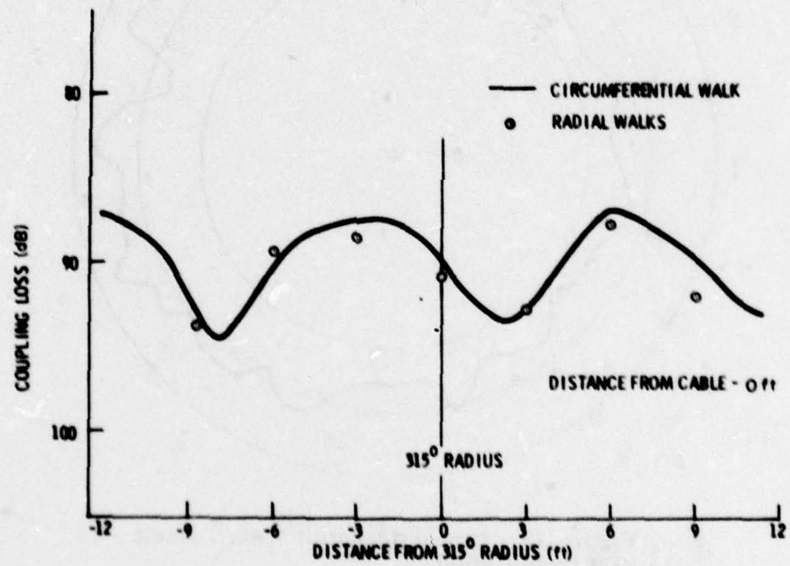

Figure 12. Comparison of Coupling Loss Variation of Circumferential and Radial Walks

To simplify comparisons of performance under different conditions, the coupling loss variations shown in Figure 9 can be redrawn in a different format. For this purpose, the amplitude of each positive and negative peak of the signal in Figure 9 is tabulated as a function of azimuth. Inspection of a large number of radial walks revealed that the change in level for a radial intrusion at the intermediate

zero-crossing point could be estimated from the values of the adjacent positive and negative peaks. In addition, it was found that for each set of three values so tabulated (the estimated zero-crossing point value and the two adjacent peak values), the smallest value represented the lower bound for the response at any crossing point in that sector. Thus a new curve could be drawn in plane polar coordinates which display the minimum response expected in that azimuth sector. The curve shown in Figure 13, as well as those displayed in the polar format, was drawn in this way. The curve gives the minimum response to be expected from radial penetrations.

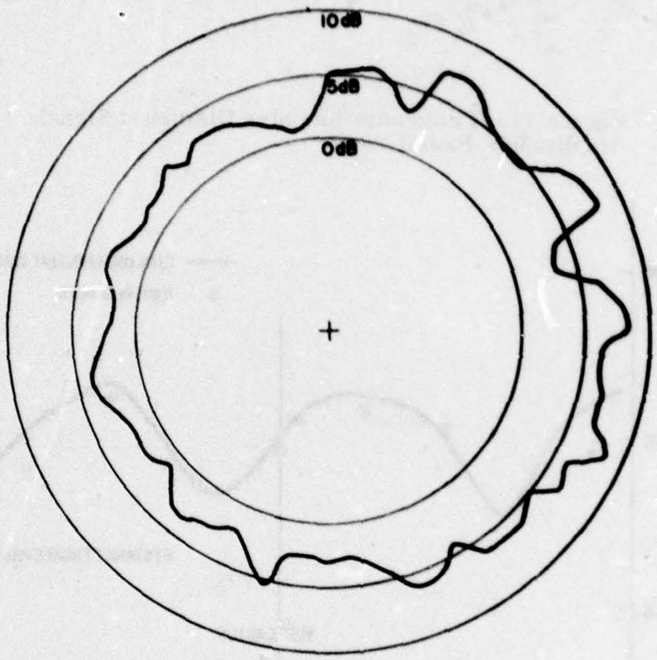

Figure 13. Circumferential Walk - Adult
(0 ft from Cable)

An important mark of an intruder detection system is its probability of detection. This quantity is easily obtained from the values of response tabulated for the preparation of the polar format. To obtain this quantity, it is only necessary to tabulate the fraction of response values equal to or less than a selected threshold (1 dB for example). This calculation was repeated for a number of threshold values. The results for the curve of Figure 13 are plotted in Figure 14 and identified by the curve labeled "at cable." The probability of detection P_D should be defined as the

probability of detecting an intruder penetrating at a location selected at random if a certain change in received signal is required to declare a detection. However, this definition—although consistent with that used in intrusion detection systems, does not correspond to the one conventionally applied to radar systems.

With some limitations, system performance is not critically dependent upon the diameter of the cable circle. Therefore, the majority of the tests were performed with the ported cable arranged in a circle having a perimeter of 500 ft (diameter = 160 ft). Results with the use of two other perimeters will be discussed briefly.

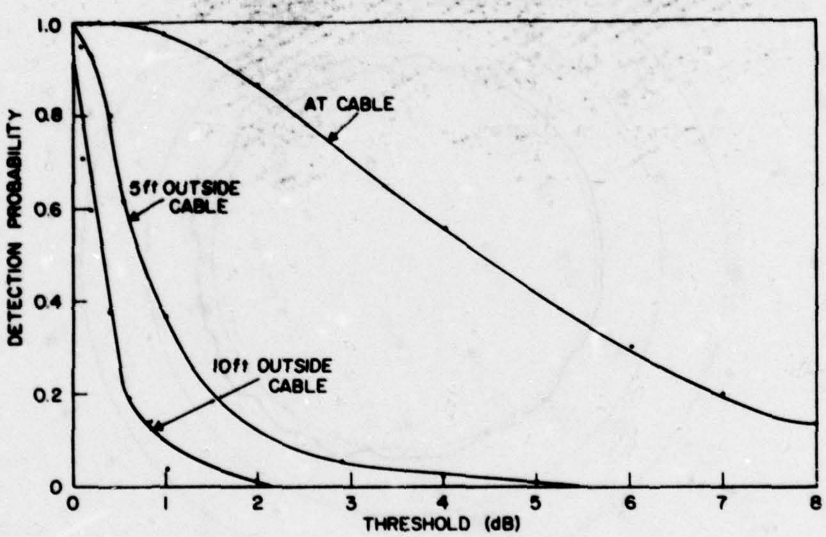

Figure 14. Detection Probability vs Threshold Values

4.2 Protected Zone: 500-ft Perimeter

Initial tests determined the detection sensitivity of the system using an adult as the intruder. Figures 13, 15, and 16 illustrate the system response for an adult walking around the cable at different distances. The polar plots should be viewed together with the detection probability graph when estimating the detection performance of a system configuration. Although the response shown in Figure 13 varies, there are no dead spots and the data from Figure 14 show that there is a P_D of 0.98 when the threshold is set at 1 dB. The value of this threshold relative to signal changes produced by false and nuisance alarms is the true indicator of system performance. The relative insensitivity of the system beyond the immediate vicinity

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of the cable is an important feature. Vehicles and/or personnel should be able to operate in adjacent areas without causing alarms. In this example, the probability of detection is reduced to about 9 percent, 10 ft outside the cable when the threshold is set at 1 dB.

The following series of experiments tested system response to individual intrusions by one adult and two children whose physical dimensions are given in Table 1.

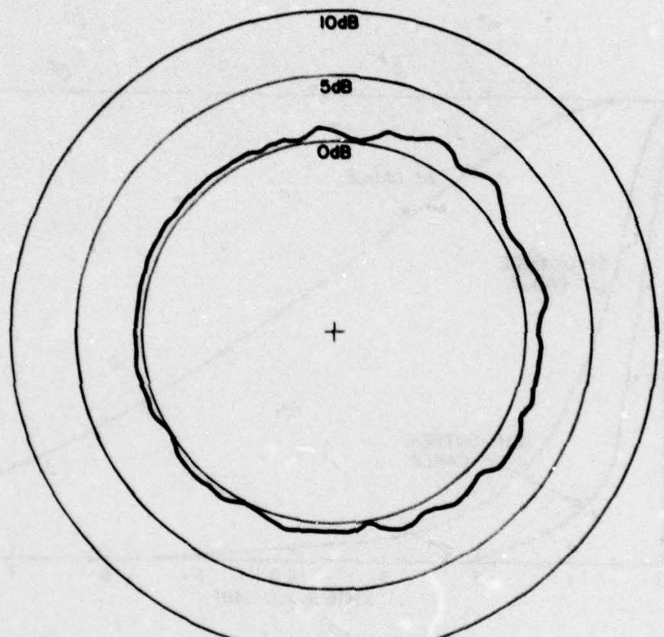

Figure 15. Circumferential Walk - Adult (5 ft outside Cable)

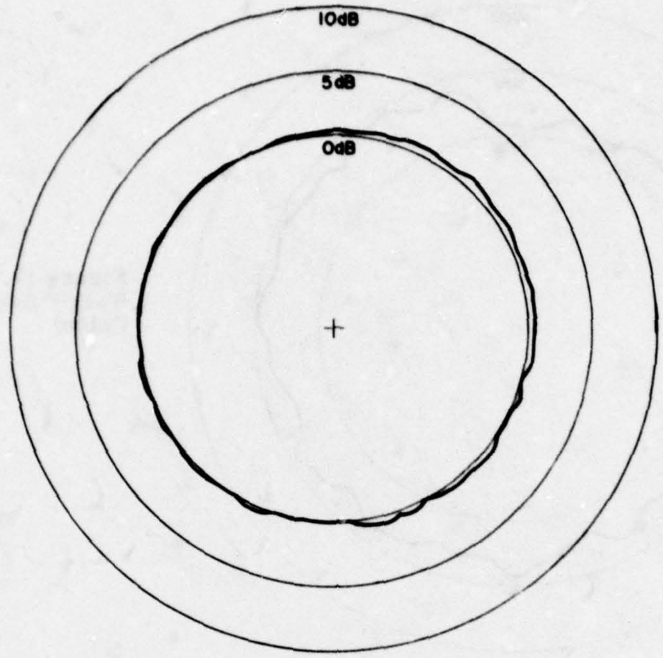

Figure 16. Circumferential Walk - Adult
(10 ft outside Cable)

Table 1. Dimensions of Adult and Children Used in Measuring System Response

Intruder	Height (inches)	Weight (pounds)	Percentage of Man's Height	Percentage of Man's Weight
Man	68	154	-	-
Girl	53	65	0.78	0.42
Boy	42	40	0.61	0.26

Figures 17, 18, and 19 show the system response for the man, the girl, and the boy, respectively. The probability of detection is shown in Figure 20. For the man, there is a P_D of 0.98 probability, given a 1 dB threshold; the system response for the girl differs only slightly from that of the man. Current system requirements* define intruding individuals as weighing 75 pounds or more (although detection of targets weighing between 50 and 75 pounds may be required for some applications).

*Reference 6, p 11.

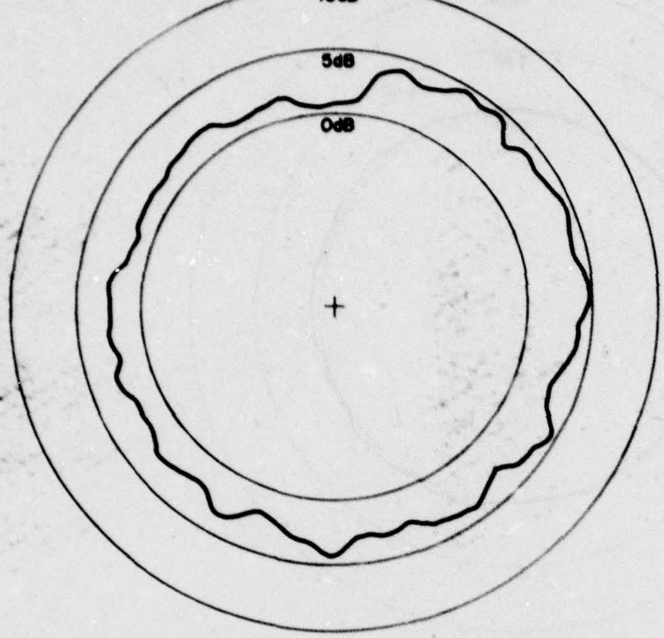

Figure 17. Circumferential Walk - Adult (0 ft from Cable)

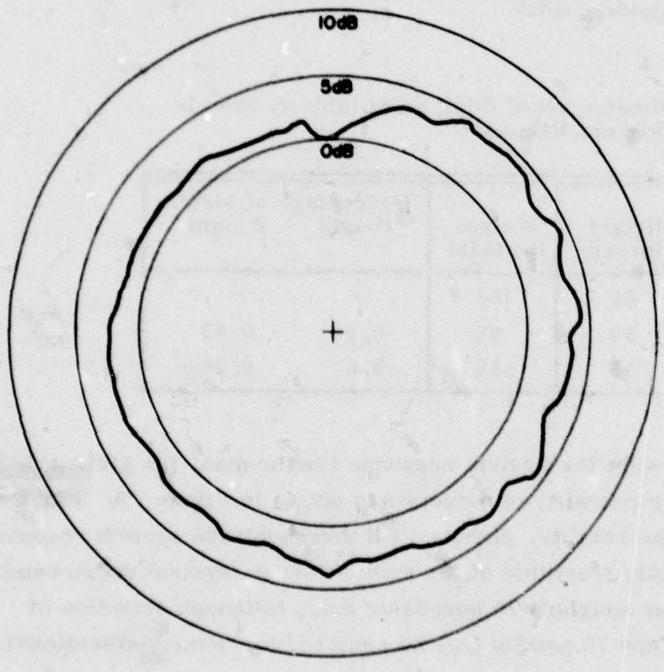

Figure 18. Circumferential Walk - Girl (0 ft from Cable)

Figure 19 shows that, for the boy, the response was approximately 1 to 2 dB lower than that for the girl. Figure 20 clearly shows the reduced probability of detection for the boy.

All previous experiments tested system reaction to an intruder in the absence of resources. The next series determined the effect on system performance by an isolated resource—a 2-1/2 ton military truck, measuring approximately 22 ft in length, 7 ft in width, and 12 ft in height—placed within the perimeter of the ported coaxial cable. For easier visualization, the isolated resource is shown in Figure 21.

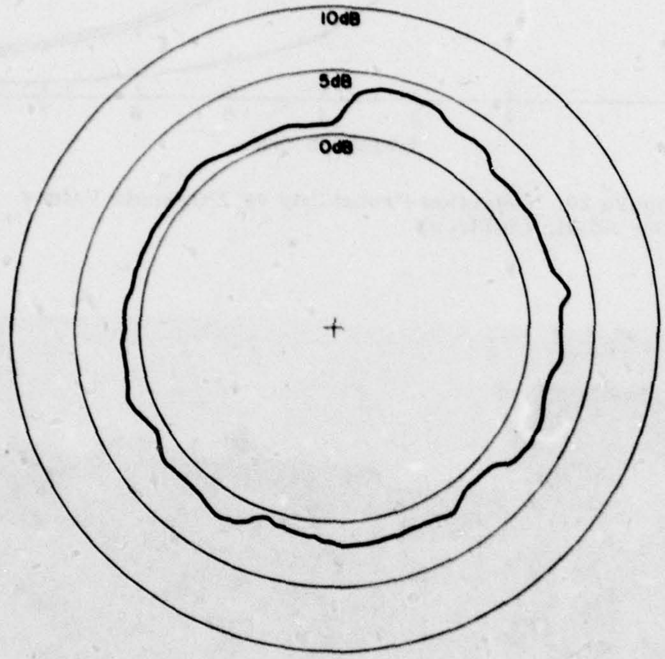

Figure 19. Circumferential Walk - Boy
(0 ft from Cable)

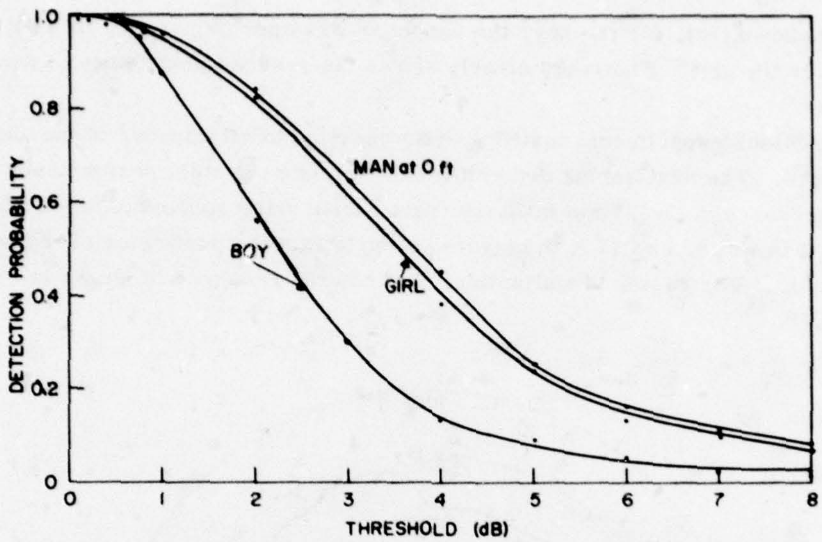

Figure 20. Detection Probability vs Threshold Values (One Adult, Children)

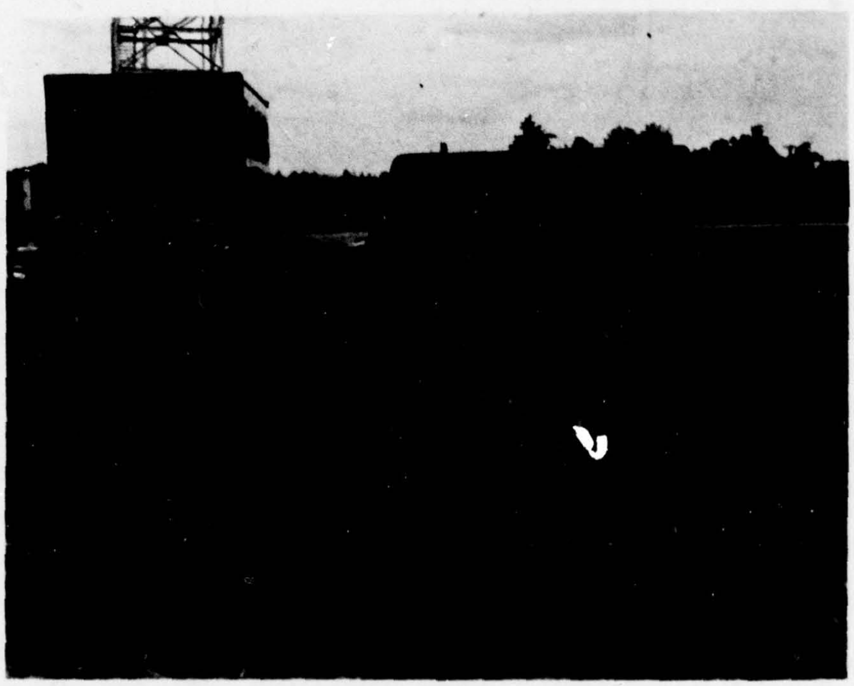

Figure 21. Photograph of Trucks Used in Experiments

Figures 22 to 25 were made with the 2-1/2-ton truck placed at distances of one, twenty, forty, and sixty feet from the centered monopole, respectively. Orientation of the truck was as shown schematically in the figures. The most important result of this series of tests was that the truck, even when placed within one foot of the receiving monopole, did not create any dead spots in the circumferential coverage. Further, the disturbed signal amplitudes did not vary greatly from those recorded when the resource was not present. Thus the orientation of the resource with respect to the antenna is noncritical. In operational use, the system could be set up quickly and easily, giving the expected protection without careful and critical alignment.

Next the system was tested with clustered resources. In the first series of tests, two automobiles were placed 12 ft apart, one on each side of the monopole, centered within the cable perimeter as represented in Figure 26. The figure shows that adequate coverage is obtained around the entire perimeter, though there is a drop in signal amplitude in the last quarter segment caused by the attenuation of the CERT's cable. The complete circumferential coverage indicates, as in the case of a single resource, that no significant shadowing or masking occurs even when the resource is directly in line with the intruder and the receiving antenna. This occurs because at 75 MHz, rf energy diffracts around the resource(s), eliminating any dead spots in the coverage.

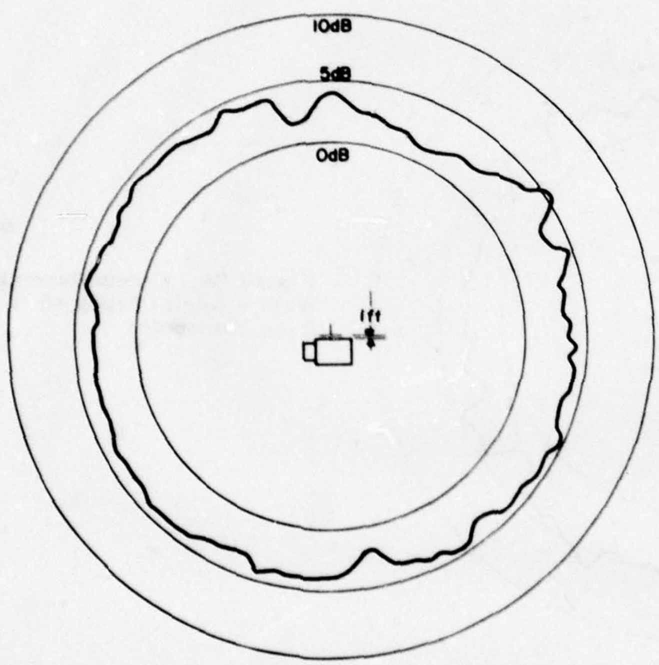

Figure 22. Circumferential Walk - Adult (Truck 1 ft from Monopole)

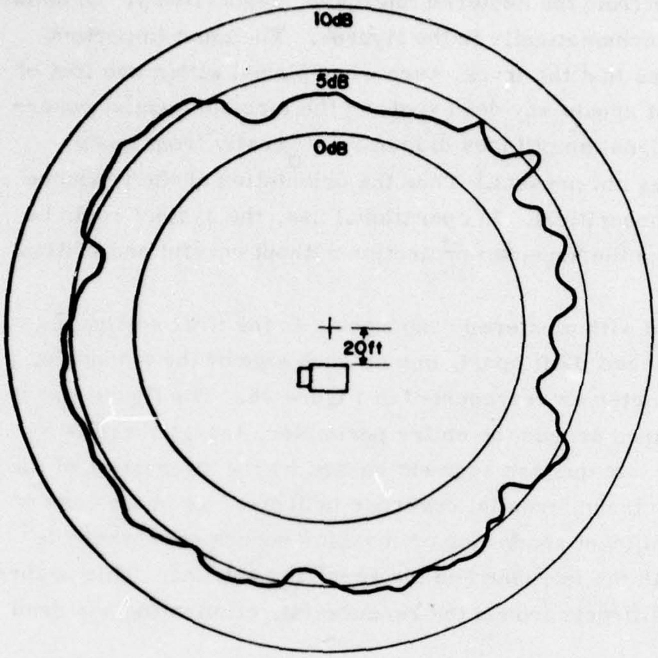

Figure 23. Circumferential Walk - Adult (Truck 20 ft from Monopole)

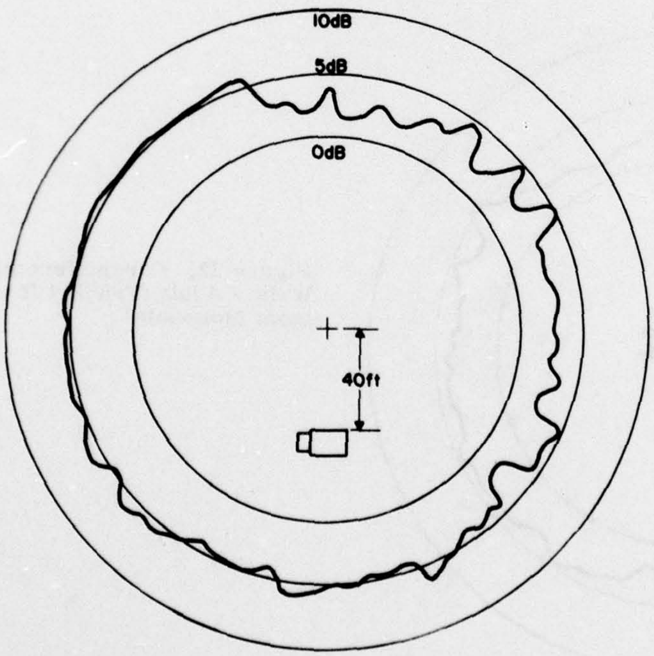

Figure 24. Circumferential Walk - Adult (Truck 40 ft from Monopole)

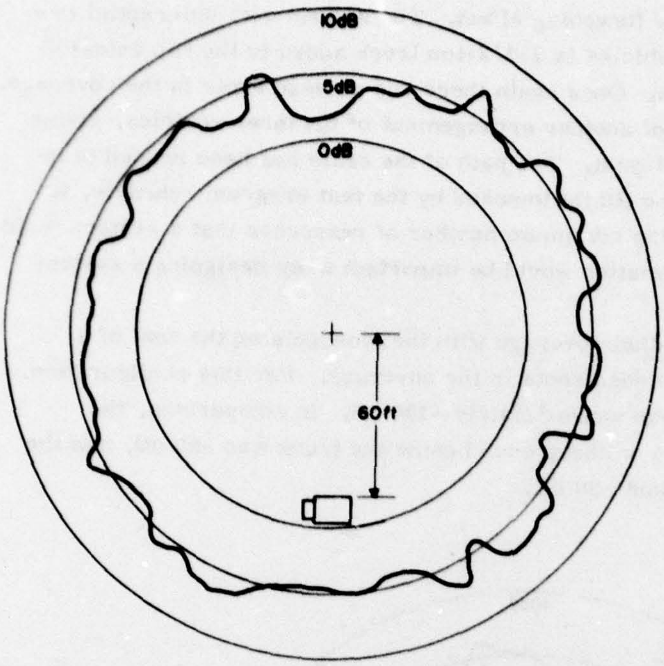

Figure 25. Circumferential Walk - Adult (Truck 60 ft from Monopole)

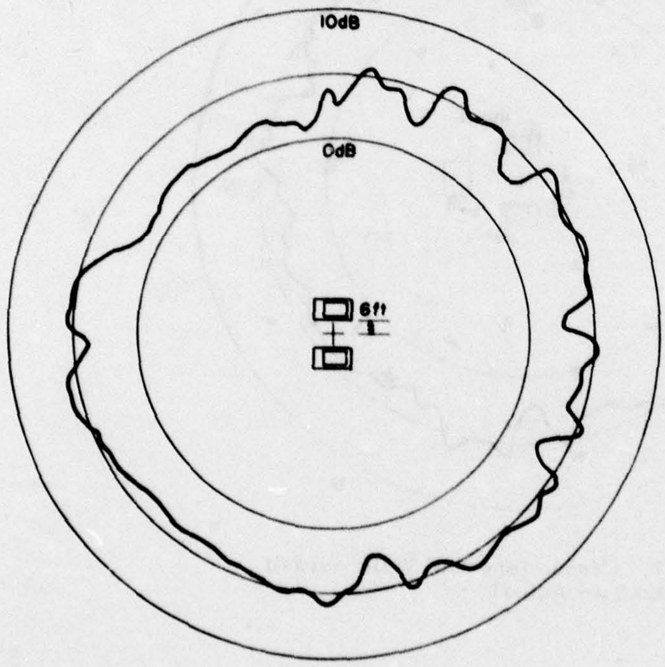

Figure 26. Circumferential Walk - Adult (Two Autos)

Figure 27 demonstrates the foregoing effect. The system circumferential response is shown where three vehicles (a 2-1/2-ton truck added to the two autos) are placed around the monopole. Once again there are no dead spots in the coverage.

Figure 28 is a photograph of another arrangement of the three vehicles, giving a picture of a possible system layout. The path of the cable has been penned in to make it visible. Due to the time limits imposed by the test program schedule, it was not possible to determine the maximum number of resources that a system could protect adequately. This information would be important when designing a system for field use.

Figure 29 shows the azimuthal coverage with the monopole on the roof of a 2-1/2-ton truck. There are no dead spots in the coverage. For this configuration, quiescent level coupling loss was approximately -100 dB. In comparison, the coupling loss with the monopole on the ground beside the truck was -95 dB, and the monopole without the truck, about -90 dB.

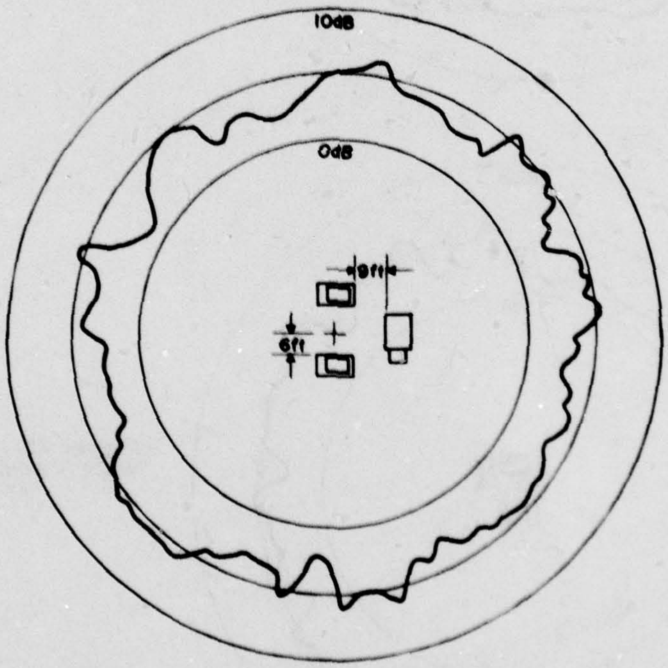

Figure 27. Circumferential Walk - Adult (Truck and Two Autos)

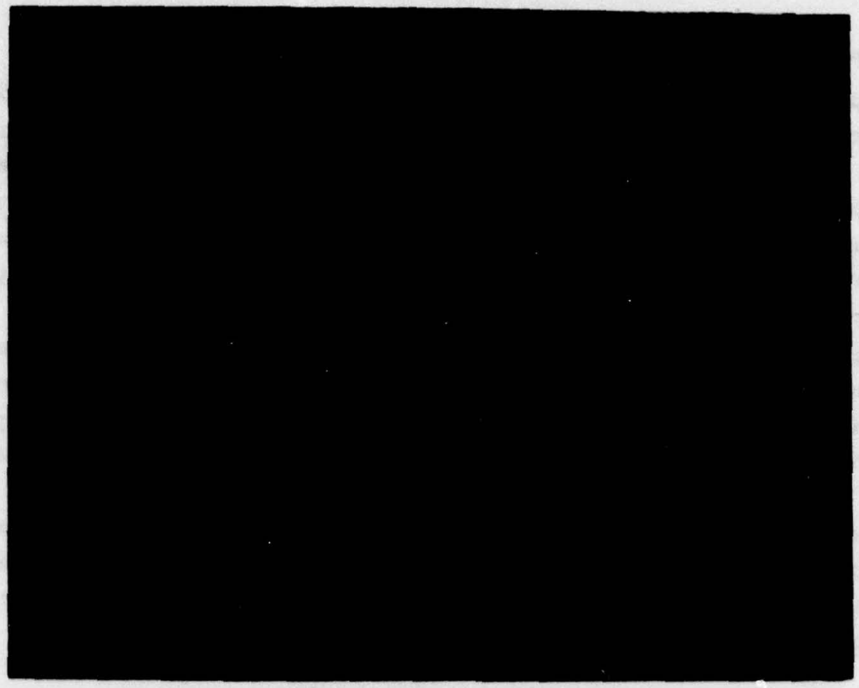

Figure 28. Photograph of Three Vehicles within Protected Zone

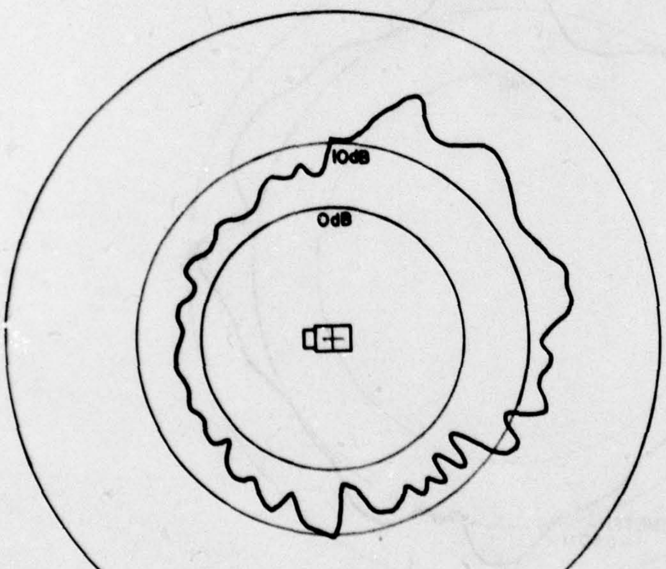

Figure 29. Circumferential Walk - Adult (Monopole on Truck Roof)

4.3 Protected Zone: 250- and 750-ft Perimeter

In practice, the area enclosed by the ported cable will vary, depending upon the specific situation and the number of resources to be protected. For all initial testing, a 500-ft cable perimeter was used since the main purpose of these tests was to probe basic system operations. It was assumed that the use of widely varying setups would cause only a minimal change in system response as a function of the length of the cable perimeter. To support this supposition, supplementary tests were performed using cable perimeters of 250 ft and 750 ft.

Figure 30 shows the system response for a cable perimeter of 250 ft without a resource present and Figure 31, with a 2-1/2-ton truck placed inside the perimeter, within a few feet of the monopole. Some blocking did occur at 270° and nearby azimuthal angles, where the truck was in direct line between the monopole and the man.

Except for the expected drop in the over-all system signal levels, no appreciable change occurred in system response when the ported cable perimeter length was increased to 750 ft. It is reasonable to conclude that the cable perimeter length, with some limitations, is not a critical parameter.

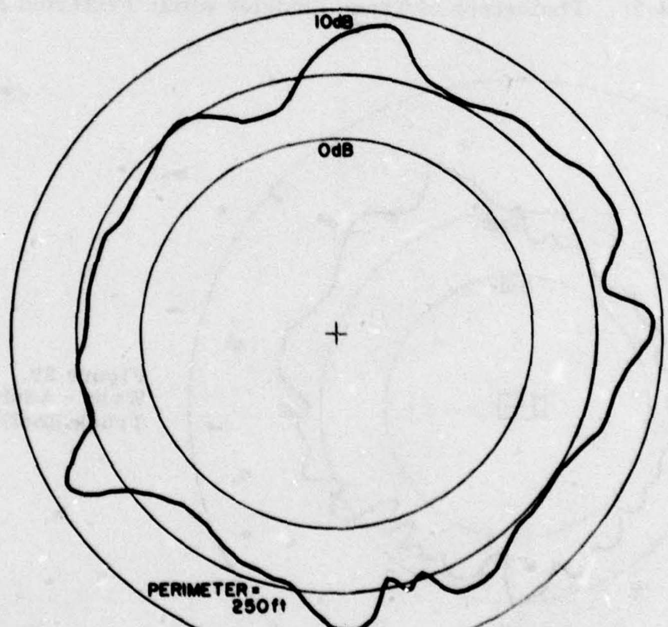

Figure 30. Circumferential Walk - Adult (250-ft Perimeter)

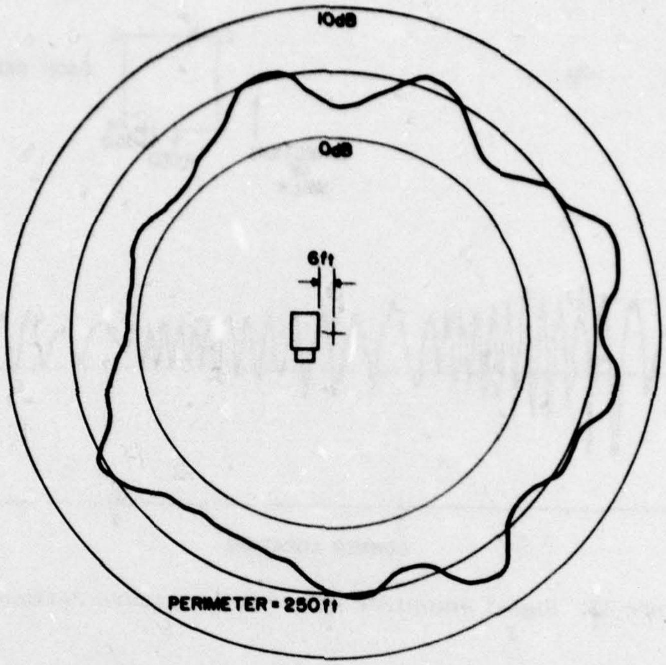

Figure 31. Circumferential Walk with Truck - Adult
(250-ft Perimeter)

Up to this point, all tests were performed with the cable laid in a circle. Since the zone of protection follows the contour of the cable, this shape is not essential to the effective operation of the system. Brief tests were conducted with a square perimeter to see if there would be a drastic change in system operation because of the abrupt change in cable direction at the corners. Figure 32 shows the response for an adult walking along the outside of the square perimeter (each side = 125 ft). As shown in the figure, detection occurs everywhere along the perimeter, including the corners. However, the wavelength of the oscillations in the response is not constant. The steady increase in wavelength along each side and its abrupt change at the corners is easily explained.

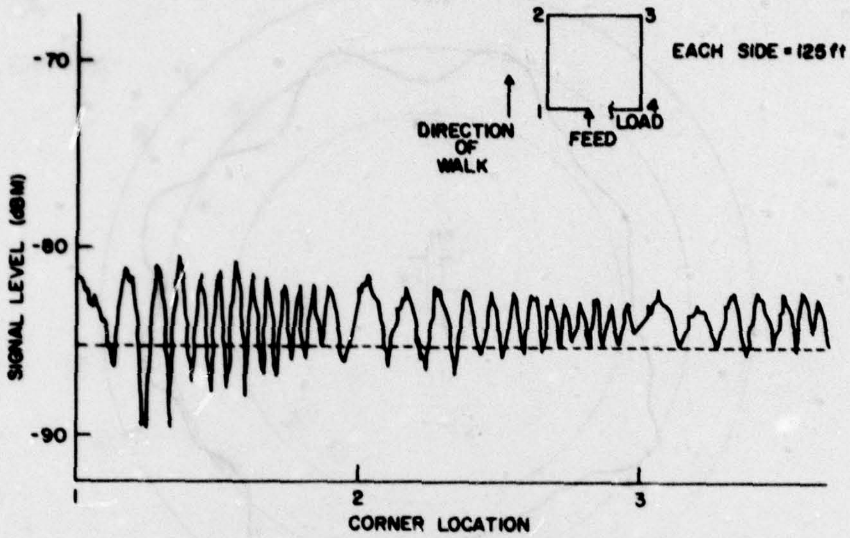

Figure 32. Signal Amplitude Response for Square Perimeter

The phase of the surface wave propagating along the cable increases with distance S, as does that of the voltage scattered by a person. The phase of the scattered voltage received at the monopole also depends on the distance between the person and the monopole. For a square 2L on a side, the total phase of the scattered voltage at the monopole is

$$\phi = k\,S + k'\,\sqrt{L^2 + (L - S)^2} \qquad (1)$$

where S is the distance from a corner. The wave numbers k and k' are associated with the surface wave and the propagation to the monopole, respectively. Interference between this voltage and the quiescent signal received in the absence of an intruder is responsible for the periodic variation in received power as a person walks along the perimeter. It is clear from Eq. (1) that the effective wave number of these oscillations increases monotonically along each side. Its value ranges from $k - \frac{k'}{\sqrt{2}}$ at one end of a side to $k + \frac{k'}{\sqrt{2}}$ at the opposite end. Midway, the effective wave number is k and the wavelength of the oscillations is equal to that observed for a circular shape. For a circle, the second term in Eq. (1) is zero because the distance from the person to the monopole does not change as he walks along the cable.

One of the requirements of intrusion detection systems is that when necessary a certain portion of the activated perimeter can be deactivated to allow entry of vehicles and/or personnel without causing nuisance alarms or shutting off the

entire system. Figure 33 is a schematic layout of one approach to the solution of this problem. As shown, an RG-8 transmission line cable, fastened to the ported coaxial cable, can be switched in and out of the system. When switched in, the RG-8 carries rf energy instead of that portion of the ported coax to which it is attached.

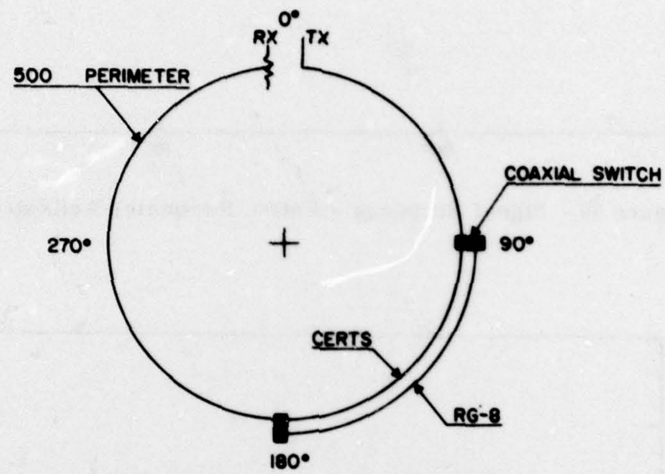

Figure 33. Schematic Diagram - Selected Partial Perimeter Deactivation

Figure 34 shows system reaction with the RG-8 switched out; all azimuthal angles are protected. In Figure 35 the RG-8 cable is switched in: Here the system does not react for that portion of the cable perimeter where the RG-8 carries the energy. This portion could be used as a controlled entry point without causing any nuisance alarms and without having to deactivate the entire system. In these tests, the quarter length portion of the perimeter deactivated was chosen randomly. No tests were performed to determine how narrow the deactivated entry point could be.

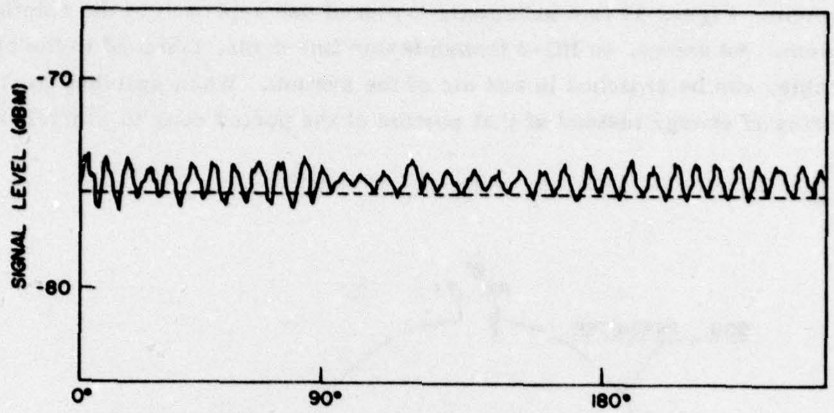

Figure 34. Signal Response - Entire Perimeter Activated

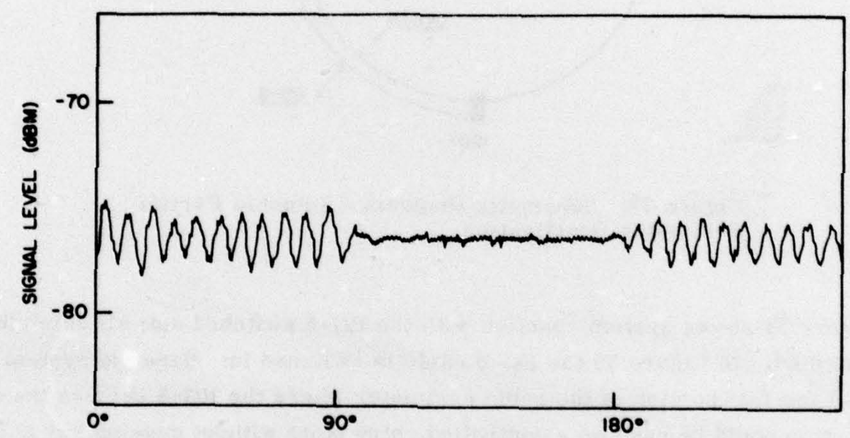

Figure 35. Signal Response - Selected Segment of Perimeter Deactivated

5. AIRCRAFT PROTECTION

As stated at the outset, this report is one of a group dealing with detection systems for isolated high value resources. Two of these reports[2, 3] deal with experiments performed using B-52 and C-5A aircraft. Since the two reports include all details of the tests, only summaries of the results will be given here.

Generally, results of the tests established the feasibility of using the monopole-ported coaxial cable system as an intrusion sensor for aircraft protection. The

system operates at 75 MHz and uses a transmitting ported coaxial cable that surrounds the aircraft, and a receiving monopole positioned within the circle described by the cable.

Tests with the B-52 aircraft (see Figure 36) showed that (1) shadowing by wheels, wing tanks, and similar obstacles did not occur; (2) wind-induced airframe motion had little effect on the false alarm rate; and (3) the detection zone was contained and well-defined. Therefore, nearby vehicles and personnel did not interfere with the system. The position of the monopole within the cable had little effect on detection sensitivity, even where aircraft wheels blocked the line of sight from the intruder to the monopole antenna. With the monopole positioned behind the front wheels, sensitivity to wind-induced wing motion was eliminated. Other flapping objects such as engine cover lanyards and safety flags did not affect system response.

Figure 36. Photograph of Parked B-52

Tests also showed that vehicles moving more than 10 ft outside the cable would not be detected. This was due to the rapid decay of the rf field outside the cable, enabling maintenance crews and other personnel working nearby to move freely

without activating an alarm. No difference in performance was observed when the ported cable lay on plain concrete, reinforced concrete, or grass. Measurements made with similar systems have shown that snow, ice, or rain do not adversely affect system operation.

The findings from tests on the B-52 aircraft apply to the C-5A (Figure 37) if a slightly modified setup is used. The modification is necessary because of the much larger size of the C-5A, and because when the aircraft is in the "kneeling" configuration, the fuselage is only 15 in. above the runway. In this position some masking of the detection signal occurs, but by using two monopoles, one on each side of the fuselage, complete circumferential coverage is restored.

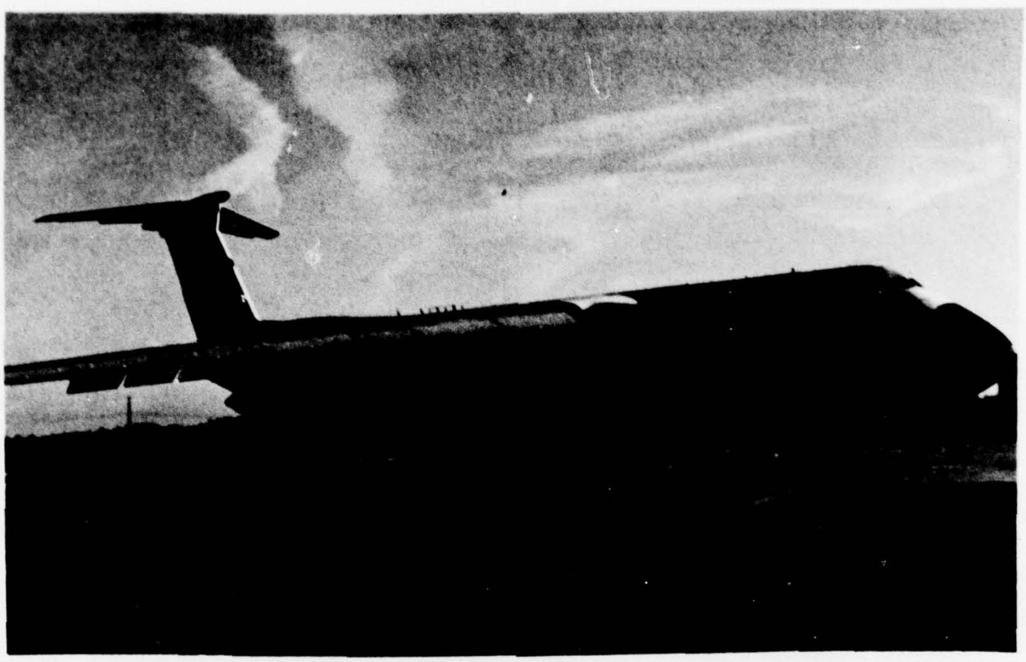

Figure 37. Photograph of Parked C-5A

6. SUMMARY AND CONCLUSIONS

This report contains the results of tests made to determine the characteristics of a monopole-leaky coaxial cable sensor and its possible security applications.

The system provides full azimuthal coverage with VHF operation and is resistant to signal masking caused by isolated or clustered resources within its protective boundaries. The comparable size of VHF wavelengths and humans helps to discriminate between real intrusions and false (or nuisance) alarms.

The receiving element is a simple quarter-wavelength monopole having a narrow passband that filters out extraneous signals. The zone of detection is concentrated in the area between the cable and the monopole, with its outer boundaries defined by the contours of the cable's configuration. This permits work crews and maintenance vehicles operating near the protected area to move freely without tripping an alarm. Adding a length of leaky coaxial cable parallel to the energized cable (with appropriate switching units) creates a passway that can be activated wherever a controlled entry point is desired.

Power requirements are minimal; the use of small power supplies and light ancillary equipment contributes to the system's portability. Positioning of the receiving monopole, leaky coaxial cable and resources is flexible. System performance is not dependent on cable contours or length. These characteristics emphasize the system's versatility and its potential for use in quick-reaction mobile configurations.

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